

# Slope Stability Analysis in Two or Three Dimensions

## Microcomputer Program Abstract

### Program Features

- General two or three-dimensional slope geometry with multiple material layers.
- Bishop's Simplified and Janbu methods of analysis.
- Simple, self-explanatory input and interactive editing.
- Mesh generators for general or axisymmetric geometries.
- Simultaneous checking for data errors during input.
- Coulomb isotropic, anisotropic or non-linear strength models.
- Discontinuities which can form parts of the sliding surface.
- Pore-pressure ratios or multiple piezometric surfaces.
- Ellipsoidal, spherical, cylindrical or composite sliding surfaces.
- Automatic searches for the critical sliding ellipsoid/circle.
- Wedges and general non-rotational 2D or 3D sliding surfaces.
- External point loads, earthquake acceleration, tension cracks.
- Optional detailed printout of column forces and dimensions.
- Built-in screen, printer and plotter graphics: cross-sections, 3D isometry, fence diagrams.

W. S. Y. 87



## Introduction

CLARA is a slope stability program for IBM compatible microcomputers, suitable for problems in soil or rock. It has two selectable forms:

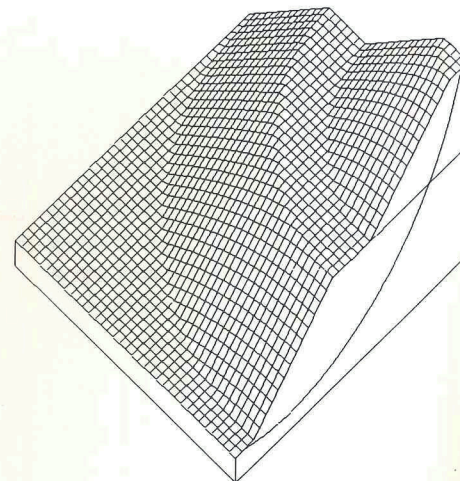
**The two-dimensional (2D) configuration** is a highly user friendly, full featured program analyzing circular and non-circular sliding surfaces using Bishop's Simplified or Janbu Methods.

**The three-dimensional configuration** uses much of the same program code. It can analyze ellipsoidal or spherical sliding surfaces, complex wedges or general 3D surfaces. CLARA accounts for complex 3D stratigraphy, several piezometric conditions, discontinuities such as weak planes or faults, external loads and three material strength models. Automatic searches can be conducted for critical ellipsoidal or composite surfaces. Three-dimensional surfaces can be fully specified by the user, to back analyze known failure geometries.

## User Interface

CLARA's user interface has been designed for maximum convenience and efficiency. All its modules run concurrently in the memory, so that it is never required to transfer data between editing, plotting, analysis and other functions. Two types of built-in editor are available. Data is checked for errors as it is entered or changed.

The geometry handling modules resemble a 3D CAD program, which generates 3D geometries from the least amount of user-supplied information. There is a wide range of built-in graphics functions both for rapid checking of geometries on screen, and for presentation graphics drawn by a laser printer or a plotter. Output interface to AutoCAD (TM) is also built in, to facilitate further processing of graphic images.

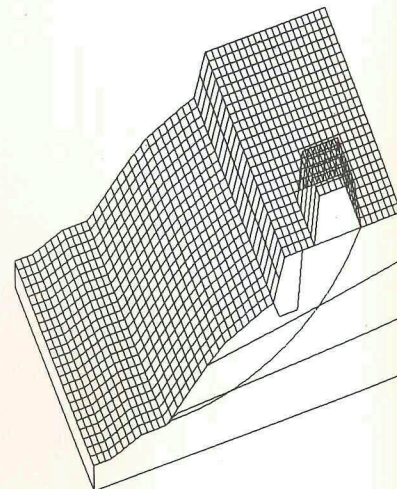


## Solution Algorithm

The solution uses extensions of the well known Bishop's and Janbu Simplified Methods of Slices into three dimensional Methods of Columns. The extension originated in independent work of at least four researchers\*. This is not surprising, because it involves only a direct application of the assumptions proposed by the original authors (Bishop, 1955, Janbu et al., 1956).

Verification tests have been conducted, comparing CLARA's results to other 2D and 3D solutions. A copy of a paper describing the testing program is included in the user's manual (Hung, Salgado and Byrne, 1989).

\*For a partial bibliography see Hung, O., *Geotechnique*, 37, No. 1, pp. 113-118, 1987.



FILE EXAMPLE2.CLA

RUN: TRIAL SURFACE

### GRAPHICS MODULE

Device: S (or ANY KEY): Screen Only  
 P Plotter: Type 1; Plot Width 200 mm  
 M Laser Printer  
 A AutoCAD (tm) .DXF Plot File

DEVICE SELECTION -&gt;

Plot Type: D Downslope Section (2D)  
 T Transverse Section (2D)  
 S Sliding Surface Isometry (3D)  
 G Ground Surface Isometry  
 M Material Surface Isometry  
 P Piezo Surface Isometry  
 F Fence Diagram (3D)  
 R Rotate View Angle

PLOT SELECTION -&gt;

CLARA

3-DIM, MESH 100 X 180

ESC TO GO TO PREVIOUS MENU

DATA FILE EXAMPLE6.CLA

BEING REVIEWED

CROSS-SECTION 3 AT X = 150.00

MATERIAL SURFACE NO. 1

	Y-COORDINATE	Z-COORDINATE
1	0.00	80.00
2	170.00	240.00
3	240.00	300.00
4	340.00	340.00
5	340.00	340.00
6	440.00	340.00
7	560.00	400.00
8	630.00	460.00
9	680.00	465.00
10		
11		
12		
13		
14		
15		
16		
17		

#### INSTRUCTIONS:

- All lines start at Y= 0.00
- All lines end at Y= 680.00
- No lines can cross each other
- Press C to copy the next point from the previous line
- Press I to insert a point
- Press D to delete a point

#### MESSAGES:

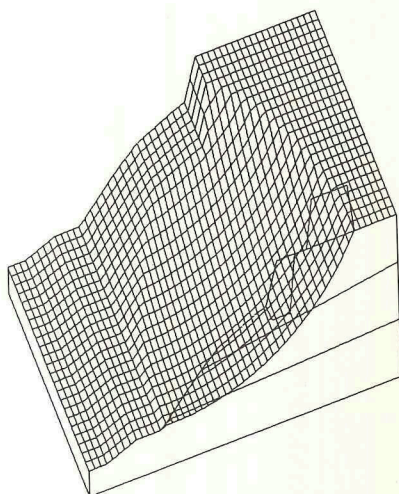
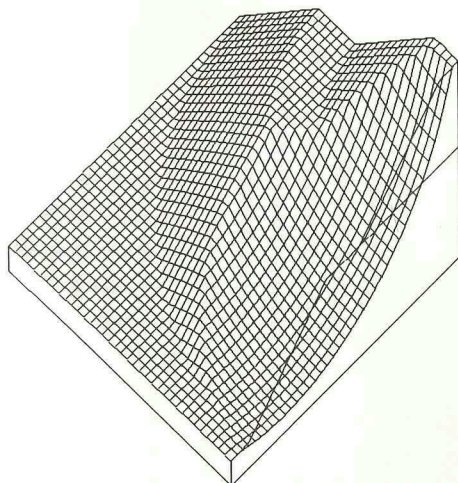
!! LINES CROSSING  
 RE-ENTER LAST POINT

CLARA

3-DIM, MESH 500 X 680

ESC TO GO TO PREVIOUS MENU



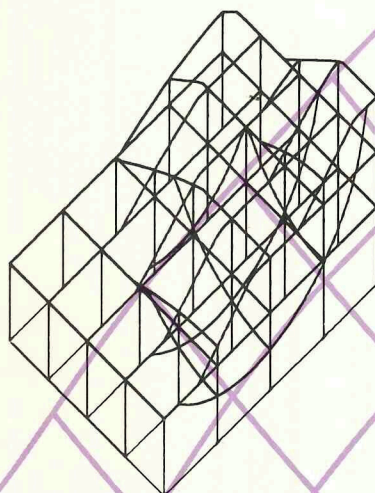


### Suggested Uses

The 2D form can be used for routine slope stability analyses, familiar to users of other programs.

The 3D form is suitable for the following types of problems:

- Slope failures under concentrated loadings on the slope face or crest, such as structures, heavy equipment or anchors.
- Slopes curved or discontinuous in plan: ends and corners of embankments, narrow excavations, earth dam abutments or spillways, bridge approach fills, conical heaps, shafts, pits, ridges, gullies and re-entrant corners.
- Narrow failure surfaces: spoon-shaped slides, failures situated between lateral constraints.
- Complex wedge geometries with or without anchor support.
- Slopes with significant lateral variation in steepness, failure surface geometry, stratigraphy, strength properties, piezometric conditions, loadings or all of the above.



### Hardware Requirements

- IBM or compatible (PC, XT, AT or PS/2 - TM) microcomputer.
- 640 K memory.
- At least one floppy disk drive. (Hard disk optional).
- CGA, Hercules, EGA, or VGA video graphics adapter.
- Optional dot matrix or laser printer for output and graphics.
- Optional plotter: HP-GL (Hewlett-Packard) DXY (Rolland plotters) DM/PL (Houston Instruments)
- Optional math coprocessor.

The program is delivered as a compiled code which fits on one standard diskette and can be copied onto the hard disk.

### Manual

An illustrated 120 page user's manual is supplied, including full instructions, example problems and sections describing the theoretical aspects of the method, verification tests, hints on maximizing results precision and a list of error messages.

### Licensing and User Support

CLARA is copyrighted but not copy protected. Each copy is identified by a serial number and the name of the authorized licensee. Main site licence, branch office and research/teaching licence are available.

Free user support is provided for one year, exclusive of the cost of long distance communication. The program is being maintained and developed by O. Hungr Geotechnical Research Inc. At least one free update will be supplied during one year period.

